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Guide for...

BATCH-DRYING IN A BIN

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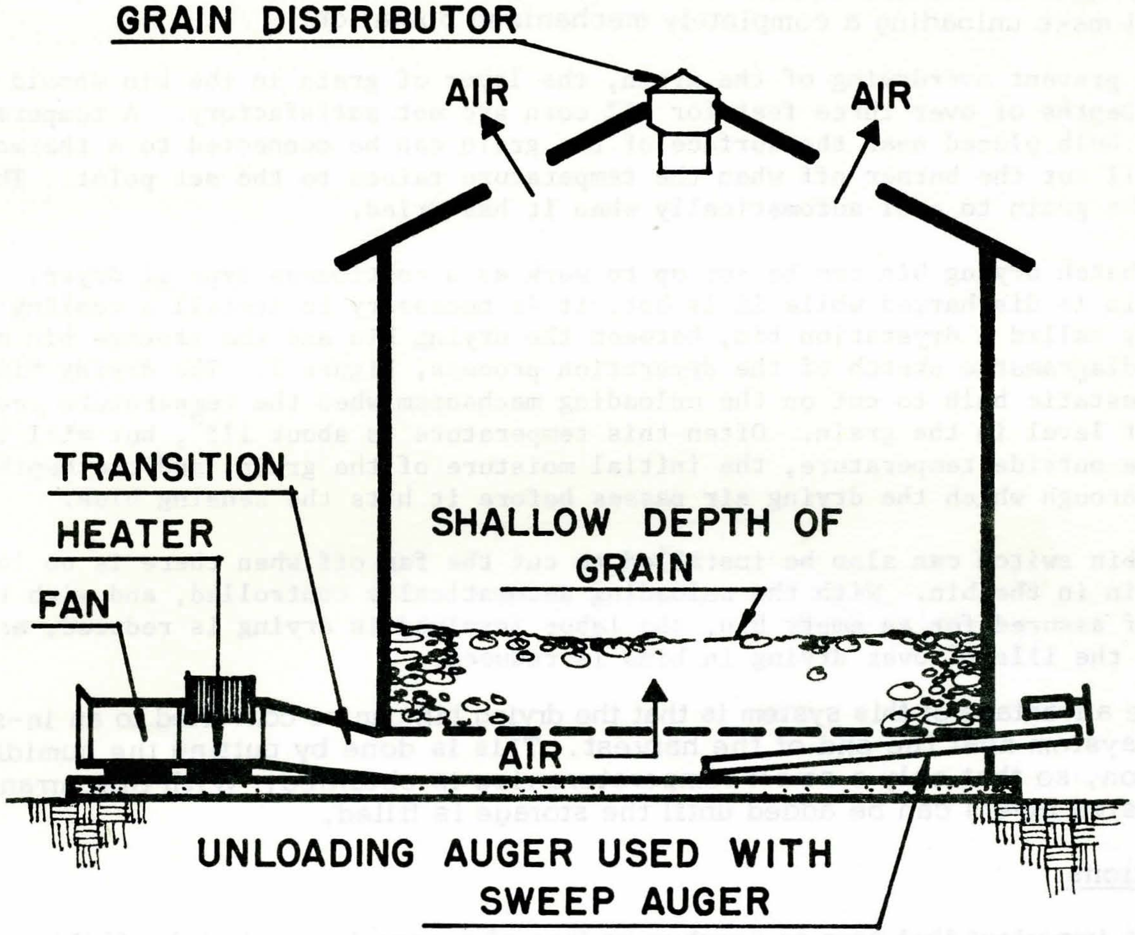
BATCH DRYING IN BIN

Figure 1



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How it Works

A typical in-storage drying bin designed for use with supplemental heat (or "controlled humidity") can be used for batch drying for greatly increased drying rates, provided the depths are kept shallow and the grain is moved and mixed after drying and cooling.

A typical drying bin (27 foot diameter, using a 10 hp fan) can dry 1,200 bushels or more of 25% moisture corn every 24 hours, when operated as a batch dryer and equipped with a burner heating capacity of 1 million B.T.U. per hour.

In operation, the fan and heater are turned on (with the humidistat out of operation) as soon as the floor of the drying bin is covered with corn or grain. More grain is added (and leveled) throughout the day as it is harvested.

The fan and heater run all night, and in the morning the heat is shut off and the batch is cooled with forced unheated air. It is then moved to final storage (and mixed) to make room for the next batch. To reduce labor demands a sweep auger system in the bin will make unloading a completely mechanized operation.

To prevent overdrying of the grain, the layer of grain in the bin should not be deep. Depths of over three feet for 25% corn are not satisfactory. A temperature sensing bulb placed near the surface of the grain can be connected to a thermostat that will cut the burner off when the temperature raises to the set point. This will allow the grain to cool automatically when it has dried.

A batch drying bin can be set up to work as a continuous type of dryer. Since the grain is discharged while it is hot, it is necessary to install a cooling bin, commonly called a dryeration bin, between the drying bin and the storage bin as shown in the diagramatic sketch of the dryeration process, Figure 2. The drying bin has a thermostatic bulb to cut on the unloading mechanism when the temperature reaches a preset level in the grain. Often this temperature is about 115^{o}, but will vary with the outside temperature, the initial moisture of the grain, and the depth of grain through which the drying air passes before it hits the sensing blub.

A bin switch can also be installed to cut the fan off when there is no longer any grain in the bin. With the unloading automatically controlled, and with the shut-off assured for an empty bin, the labor involved in drying is reduced, and some of the ills of over drying in bins is reduced.

One advantage of this system is that the drying bin can be converted to an in-storage drying system near the end of the harvest. This is done by putting the humidistat in operation, so that only a small temperature rise is obtained. With this arrangement successive layers can be added until the storage is filled.

Precautions

It is important that corn or sorghum be free of excess fine material. If this exceeds 3% to 5%, screen it out before trying to dry the grain. Fine material will restrict airflow and slow down the drying rate. If large amounts of fine material collect in one spot, the drying may be impaired and cause wet spots in the batch.

Some drying bins designed for supplemental heat (controlled-humidity) drying do not produce enough heat to be of concern, but drying-air temperatures should generally be kept below 110 degrees for seed, 140 degrees for market corn, and 160-180 degrees for feed. For immature corn, temperatures should be lower.

Corn should be leveled after every load to assure more even drying. Grain distributors sold for this purpose will save considerable work, as well as distributing fine materials more evenly.

All grain should be cooled after drying, as high temperatures can cause spoilage even in dry grain. The fan should be run for about an hour without heat to cool the grain to within ten degrees of outdoor temperature. Some drying will take place while it is being cooled, so this should be allowed for in timing the use of heated air.

Grain will dry unevenly when using heated air. At the end of the drying period the kernels at the bottom of the mass will be dryer than those at the top. Sample the grain at different depths to get an idea of the average moisture content of the batch.

The more heat used, the greater the difference in moisture between top and bottom. Use <u>no more heat than is necessary</u> to hold this difference to a minimum. The fuel rate should be adjusted to dry the batch in the time available, and no sooner. This will also avoid the necessity of turning off the heat in the middle of the night.

Corn or grain should be moved and mixed after being batch-dried with heated air so moisture can migrate from the wetter kernels to the dryer ones.

Drying Capacity

The estimated drying capacities for batch-drying shelled corn in bins of different diameters is given in Table I. The time for drying is about 20 hours at a temperature of 100° F. The drying time can be reduced considerably by using higher temperatures. When higher temperatures are used the depth of the batch should be reduced. The shallower depth will allow the higher temperature air to pass more rapidly through the batch of grain, assuring a more uniform moisture between the bottom and top. This will help reduce the chances of overdrying.

TABLE I

Estimated size of shelled corn batches (bushels) which can be dried in 20 hours at a temperature of 100° F with different combinations of bins and fans.

Bin Diam. (ft)	Fan (HP)	Moisture Content (%) 20	25	30
21	5	1100	870	660
24	7-1/2	1530	1230	900
27	10	1930	1550	1130
30	10	2280	1790	1350
33	15	2910	2340	1720
36	20	3310	2640	1900
40	25	4310	3540	2640
	Maximum depth of undried grain	4'	3'	2-1/2'

How to Determine the Fuel Rate to Use

It is desirable to adjust the fuel rate to complete drying within the time available, and not much sooner. The lowest rate that will do the job in the time available will minimize the problem of spread in moisture content from the bottom to the top of the batch, and will reduce condensation inside the bin in cool weather. It will also avoid the necessity of turning off the heat in the middle of the night.

Table II gives the expected hours to dry 25% moisture corn or sorghum down to 13% moisture with different batch sizes and heat rates.

Heat rates can usually be secured from manufacturer's information for a given burner orifice and pressure. Once this is known, it is necessary only to adjust the pressure to give the desired heat rate. The humidistat is put "out of action" by turning it down and/or removing it from the plenum chamber, or by switching over to "manual" operation at the controls.

If the heat rate for the burner is not known, it can be calculated by using the air delivery of the fan and the temperature rise of air going through the burner. Find the expected air delivery of the fan from the manufacturers data or Table III; measure the temperature rise going through the fan-heater unit, and use this formula:

Cubic feet per minute X 1.1 X degrees rise = BTU/hour

Example: A 7 1/2 hp fan, 24" dia. delivers approximately 13,600 cfm at 1 inch static pressure (drying shelled corn). Temperature rise is 70 degrees. Find the BTU/hour capacity.

13,600 X 1.1 X 70 degrees = 1,047,200 BTU/hour

With this information, look in Table II to find that drying time for a 1000-bushel batch would be about 19.1 hours.

Table 3. Typical air deliveries of fans used on drying bins.

Horsepower and diameter	Air delivery at static pressure of: 1"	2"	3"	4"
3 hp 16"	6,160	5,500	4,850	3,925
5 hp 20"	9,350	8,450	7,380	6,090
5 hp 24"	11,100	10,000	8,700	6,910
7 1/2 hp 20"	11,900	10,800	9,700	8,500
7 1/2 hp 24"	13,600	12,500	10,000	9,100
10 hp 36"	26,000	22,500	18,000	10,500

Table 2. Approximate time to dry a batch of 25% moisture shelled corn or sorghum to 13% moisture in fall weather.[a]

Burner Capacity	Hours to dry a batch size of:								
	400 bu.	600 bu.	800 bu.	1000 bu.	1200 bu.	1400 bu.	1600 bu.	1800 bu.	2000 bu.
200,000 BTU/hr.	34.2	51.6							
400,000 BTU/hr.	17.2	25.8	34.2						
600,000 BTU/hr.	11.4	17.2	22.8	28.6	34.3				
800,000 BTU/hr.	8.6	12.9	17.2	21.5	25.8	30.0			
1.0 Mil. BTU/hr.	7.6	11.5	15.3	19.1	23.0	26.8	30.6		
1.2 Mil. BTU/hr.	5.7	8.6	11.4	14.3	17.2	20.0	22.9	25.8	28.6
1.4 Mil. BTU/hr.	4.8	7.4	9.8	12.3	14.7	17.2	19.7	22.1	24.6

For 20% moisture multiply hours from table by .50
For 30% moisture multiply hours from table by 1.5
For summer drying multiply hours from table by .83
For winter drying multiply hours from table by 1.4

a/ Be sure drying air temperature does not exceed 110 degrees F. for seed, 140 degrees for market, 200 degrees for feed.

Note: Some adjustment from the values given in the tables will be needed because of the drying that takes place during cooling, effect of outdoor temperature and humidity, etc.

Finding Expected Temperature Rise

To check on the temperature rise expected, if you know the capacity of the burner, use this formula:

$$\frac{\text{Burner capacity in BTU/hour}}{\text{cfm X 1.1}} = \text{degrees temperature rise.}$$

Example: $$\frac{\text{1,047,200 BTU/hour}}{\text{13,600 cfm X 1.1}} = \text{70 degrees temperature rise.}$$

Drying-air temperatures should be limited to no more than 110 degrees for seed, 140 degrees for market, and 160-180 degrees for feed.

Table 4. Pounds of water per bushel of grain at different moisture contents.

Moisture, percent	Shelled corn and grain sorghum[a]	Wheat and Soybeans[b]	Oats[c]
35	25.4	27.8	14.6
30	20.2	22.1	11.7
28	18.4	20.1	10.6
26	16.6	18.2	9.6
25	15.7	17.2	9.1
24	14.9	16.4	8.6
22	13.3	14.6	7.7
20	11.8	12.9	6.8
18	10.4	11.4	6.0
16	9.0	9.8	5.2
14	7.7	8.4	4.4
13	7.1	7.7	4.1
12	6.5	7.0	3.7
10	5.3	5.8	3.0
8	4.1	4.5	2.3

a. A bushel of shelled corn or sorghum is defined as 56 lb. at 15 1/2% moisture; dry matter per bushel is 47.32 lb.

b. A bushel of wheat or soybeans is defined as 60 pounds at 14% moisture; dry matter per bushel is 51.6 lb.

c. A bushel of oats is defined as 32 pounds of oats at 14 1/2% moisture; dry matter per bushel is 27.4 lb.

"Shrinkage" in Drying

Since corn and grains are sold by weight, it is usual to figure "shrinkage" on a weight basis. This can be figured by the following formula:

$$\text{Initial weight} \times \frac{100 \text{ minus initial \% moisture}}{100 \text{ minus final \% moisture}} = \text{final weight.}$$

Example: 1,000 bushels of 25% moisture corn would weigh approximately 63,000 pounds. (See Table IV; dry matter is 47.3 pounds and weight of water is 15.7 pounds. Then 47.3 plus 15.7 = 63 pounds per bushel or 1,000 bushels weight 63,000 lbs.)

$$63{,}000 \times \frac{100-25}{100-13} = 63{,}000 \times \frac{75}{87} - 63{,}000 \times .862 \text{ or } 54{,}400 \text{ lb.}$$

Weight loss = 63,000 - 54,400 or 8,600 lb.

$$\text{Percent shrinkage equals } \frac{8600}{63000} \times 100 = 13.6 \text{ percent.}$$

Table V gives shrinkages for drying from typical moisture contents.

Table 5. Shrinkage (loss of weight) in drying shelled corn and grains.

Initial Moisture Content, %	Shrinkage for final moisture content of: 10%	12%	13%	14%	15%
17	7.8	5.7	4.6	3.5	1.8
20	11.0	9.0	8.1	7.0	5.3
25	16.7	14.8	13.6	12.8	11.2
30	22.2	20.5	19.6	18.6	17.2

Loss From Over-Drying

Over-drying corn that is to be marketed results in the loss of the weight of the water that could have been sold, unless the buyer gives a premium for overdried corn. These losses are given in Table VI.

Table 6. Loss in value from overdrying shelled corn and grain sorghum.a/

Moisture content When sold	Weight per bushel	"Shrinkage" loss, percent
15 1/2	56.0	0%
13	54.4	3.0
12	53.8	4.0
10	52.0	7.2
8	51.4	8.3

a/ Based on a "market bushel" of 56 pounds at 15 1/2% moisture.

Getting Extra Capacity

One way to increase capacity of this system without serious overdrying is to use less depth of batch and a higher temperature. However, it will be necessary to dry two batches per day. This means more handling, but the drying capacity with the same equipment can be increased from 35 to 50%. For example, by using a temperature of 120° F. instead of 100° F, and three-fourths of the depth shown in Table I, two batches can be dried in 18 hours (9 hours for each batch). This represents an increase of 50% in the amount of grain dried per day.

Dryeration

Another method of increasing capacity would be to use the dryeration process illustrated in Figure No. 2. This practice helps in two ways. First, time for drying is reduced since the corn is moved out of the dryer at a moisture content of 16-18%. Grain is later dried to a safe moisture level for storage in the dryeration bin. Secondly, the time for cooling the grain is not required in the batch drying bin since this is also done in the dryeration bin.

Higher temperatures for drying in the dryeration process also helps increase capacity. However, the hot corn when removed from the batch bin must be allowed to steam itself or temper before cooling and drying in the dryeration bin. This procedure of interrupting the drying process reduces the formation of stress cracks in the corn, thus reducing the tendency to break or crack when handled. Tests on this practice showed that this corn is less brittle.

To provide for smooth continuous operation it is advisable to have two or more bins to handle hot grain from the batch-drying bin.

Hot corn placed in the dryeration bin should have about four hours of time to steep before the cooling air reaches it. The first corn placed in the bin starts cooling first and a cooling zone moves through the grain just like a drying zone moves through grain that is being dried. Upward movement of air is recommended in the dryeration bin so the hot corn being added will not be immediately cooled even though the cooling fan may be operating.

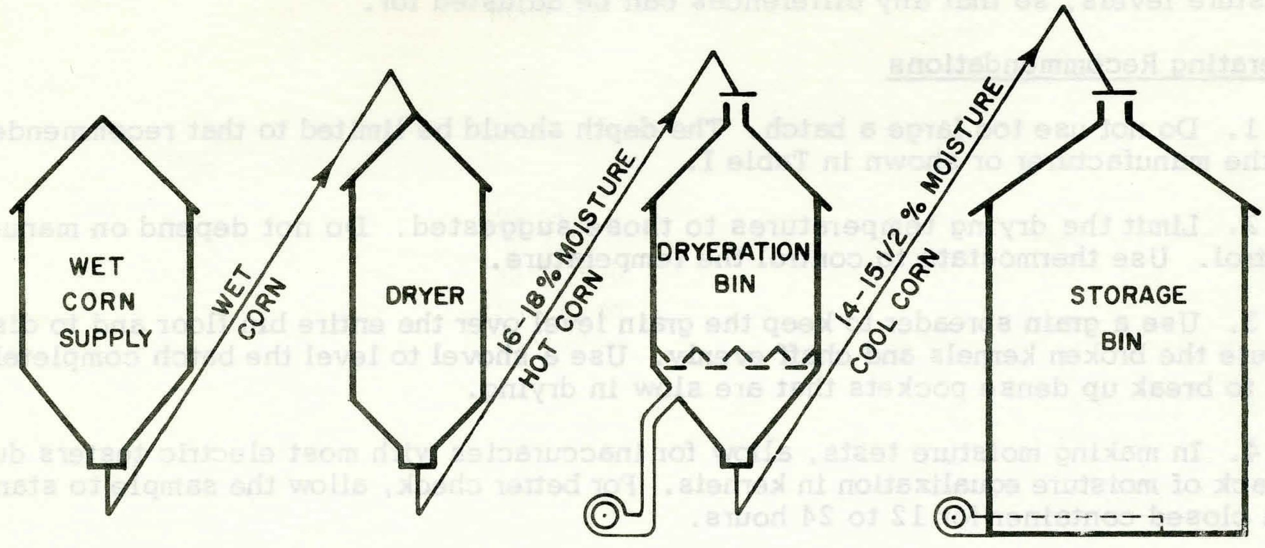
For a continuous operation two cooling bins may be used. Cooling bins may be hopper bottomed for gravity unloading, may be flat bottomed with a shielded unloading sweep, or may be flat bottomed with an unloading auger to the center of the bin. Flat bottomed bins with the unloading auger to the center, will form a hopper bottom out of the corn. Since this corn is cool and dry, no harm comes from leaving the corn in the bin throughout the season. It does cause a slight increase in pressure of the air, but this is not serious.

Air flow in dryeration bins are relatively low, 0.5 to 1.0 CFM per bushel. Drying usually takes from 8 to 10 hours. Faster air flow will cool the grain faster, but this is not good because the corn will not dry in the fast cooling process as much as it will in the slow cooling.

Figure 2

THE DRYERATION PROCESS

(BATCH OR CONTINUOUS DRYER)



Reliable fan and bin manufacturers usually provide tables of filling rates for different grains and moisture contents.

Matching the Drying System to the Harvesting Rate

With the information given in Tables I & II, it is fairly simple to select the size of batch-bin drying system needed to keep up with the rate of harvesting. Failure to recognize this relationship has resulted in the selection of "under sized" equipment. Each manufacturer can provide information on his package system, however, it should be remembered that these figures represent maximum capacity.

It is advisable to select a unit with some reserve capacity to prevent bottlenecks that will prevent delay harvest and increase field loss of shelled and ear corn.

Moisture Testers

A moisture tester is a "must" for drying operation. The three common methods used are the Brown-Duval (cooking-in-oil), the oven method, and the electric test.

Typical testers using the cooking-in-oil and oven methods require about 30 minutes to secure an answer. Electric testers give the answer in minutes. The cooking-in-oil method is the accepted standard for moisture tests.

Oven type testers (where the sample is weighed, dried, and weighed again) should be left turned on only the recommended time to avoid burning the sample.

Electric testers may give a falsely "low" reading on corn that has been recently dried with heated air. This is because they tend to measure the moisture content of the outside of the kernel. Readings with electric testers should be checked with the cooking-in-oil method (perhaps your grain buyer will do this for you) both at high and low moisture levels, so that any differences can be adjusted for.

Operating Recommendations

1. Do not use too large a batch. The depth should be limited to that recommended by the manufacturer or shown in Table I.

2. Limit the drying temperatures to those suggested. Do not depend on manual control. Use thermostats to control the temperature.

3. Use a grain spreader to keep the grain level over the entire bin floor and to distribute the broken kernels and chaff evenly. Use a shovel to level the batch completely and to break up dense pockets that are slow in drying.

4. In making moisture tests, allow for inaccuracies with most electric testers due to lack of moisture equalization in kernels. For better check, allow the sample to stand in a closed container for 12 to 24 hours.

5. Be sure to cool grain thoroughly following drying. Cooling helps equalize moisture.

6. Aerate the dried grain after it has been placed in storage, until the grain has been cooled to a temperature of 45^{o}-50^{o} F. This will help control damage from insects and molds and will help prevent moisture from accumulating on the top of the grain, particularly in large bins of 2,000 bushel capacity or more.

Material for this circular has been adopted from South Dakota State University EMC 542 "Guide to Batch Drying in a Bin," from "Modern Methods for Drying Grain in Bins," prepared by Farm Fans Incorporated, and from Purdue University AE-72 Dryeration.